Target simulation for monopulse processing

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Abstract:

Monopulse processing is a form of tracking technique, from which we can extract height, range and angle estimates of a target. Herein, we tend to obtain the angle estimate of the target, by transmitting a pulse towards the target and obtaining the echo in four different receivers. Thus looking at the target from four different quadrants, so that the angle estimates of the target can be obtained. To achieve this we simulate a target and perform Digital Pulse Compression (DPC) and Doppler filtering, by forming eight filter banks, thus separating target from stationary clutter. To obtain monopulse sum and difference pattern, Digital Beam Forming (DBF) technique is followed; wherein a planar array of number of elements is formed and these elements are divided into 4 quadrants, with each quadrants having equal number of elements. The output from each quadrant is then combined to form sum and difference pattern. A lookup table is formed by obtaining difference to sum (d/s) ratio of sum and difference pattern for corresponding angular errors. Thus now obtaining the targets in 4 receivers, we obtain d/s ratio at the target, we compare this d/s with the lookup table to obtain angle estimates.

Key words: monopulse processing, angle estimation, target simulation, Doppler filtering.

I INTRODUCTION

Monopulse processing a form of tracking technique; which can estimate range, height and angle of a target using single pulse; was first coined by Robert M. Page in 1943[1]. Most of the research works have spoken of procedure for monopulse processing and various techniques in monopulse processing. In this paper an introduction of simulation of the target essential to carry out monopulse processing is brought about.

Processing chain for a monopulse radar as shown in figure 1 will have a Digital Beam Former (DBF) which would form the monopulse beam; followed by a Digital Pulse Compression (DPC) stage which is associated with signal processing, then followed by Digital Filter Banks (DFB) essential for clutter rejection and at the end of which we will obtain the difference to sum (d/s) ratio using which we can obtain the offset angle [2].

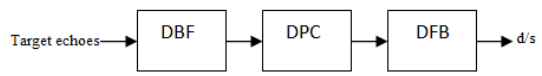

Figure 1 Process flow for monopulse processing

Hence the main aim of this paper is to come up with simulation of a target essential to test this chain.

II SIMULATION OF THE TARGET

Simulation of the target involves formation of a Pulse Repetition Frequency (PRF) of certain frequency. This PRF is modulated by mounting on a P4 code which is defined as [3]

$$\varphi = \left(\frac{\pi}{N}\right)\left((i-1)(i-N-1)\right) \qquad (1)$$

Where 'N' gives length of the code and 'i' ranges from 1 to N [3]. In this paper we have considered a P4 code of specific number.

This PRF will now act as a transmitted pulse and at the reception this pulse is received by the monopulse receivers with an offset from the boresight for verification purpose so that we can match this offset introduced to the end result what we get.

III DOPPLER IN SIMULATION OF THE TARGET

Doppler filtering as is done to separate clutter from the target. In this paper we make use of this property to introduce Doppler into the target, form filter banks and carryout FFT algorithm to separate targets from clutter [4].

To begin with, we generate 8 different phase values in its complex form; i.e. we sample the PRF with the sampling frequency as given below

$$fs = \frac{PRF}{N} . m \qquad (2)$$

Where 'fs' is the sampling frequency, 'm' is the Doppler and 'N' is the number of phase values.

We now obtain the complex form of these samples which give out the phase values.

$$\text{phase values} = \cos(\varphi) + i \sin(\varphi) \qquad (3)$$

These phase values are now multiplied with the PRF formed in the earlier discussion to form N different PRFs in a single Coherent Pulse Integral (CPI).

These PRFs are now received individually and subjected to monopulse chain to obtain the required offset angle.

IV ELEVATION PHASES

The target so formed is now required to be received by the receivers and test the monopulse chain for the target simulated. In order to achieve this we form a planar array and are subdivided into 4 quadrants each having equal number of elements [5]. The response from these array elements is oriented in such a way to form monopulse sum and elevation difference patterns. These responses are now correlated with response from the target. Hence the target is now received by monopulse receivers at few offset angles from the boresight (Eg.1.5^o). The received target is then subjected to DPC which involves convolution of the received echo and monopulse sum and difference patterns [6]. Hence concatenating all the responses we obtain 'N' different filter banks, implementing Fast Fourier Transform (FFT) algorithm we separate target from the clutter, obtain d/s ratio and obtain the essential offset angle.

V IMPLEMENTATION

In order to simulate the target as mentioned above in the earlier discussions we consider a P4 code.It is then modulates a PRF of few Khz. Hence the PRF so formed is shown in figure 2.

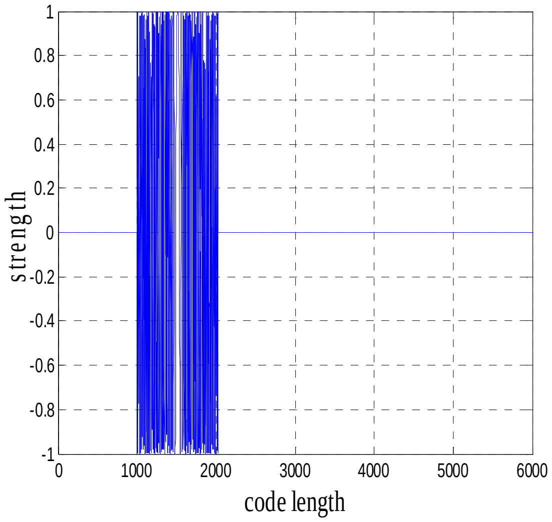

Figure 2. PRF, modulated by P4 code of length 1024

This is followed by introducing Doppler phase values. In this paper we consider 8 number of different phase values. We then obtain 8 different phase values as per equation (3). The phase values so formed are shown in figure 3.

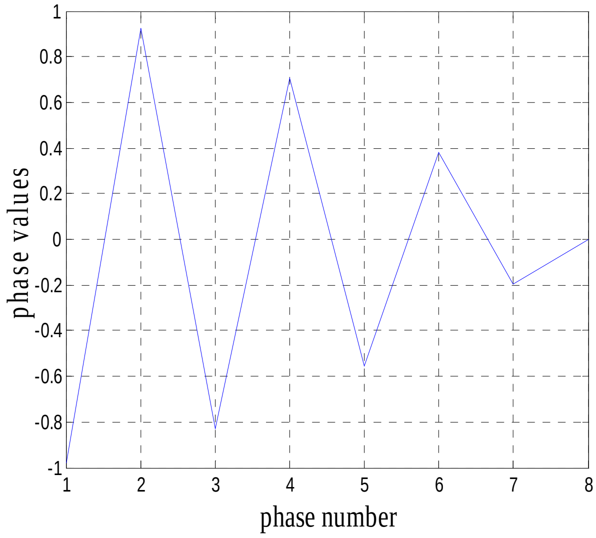

Figure 3. Eight complex phase values generated.

These phase values as mentioned above is multiplied with above shown PRF and forms eight different PRFs. Hence this forms the essential target.

In order to test the monopulse chain for the target so formed we need to receive the target on the monopulse receivers. Figure 4 shows the received target after correlating with monopulse sum and difference beam.

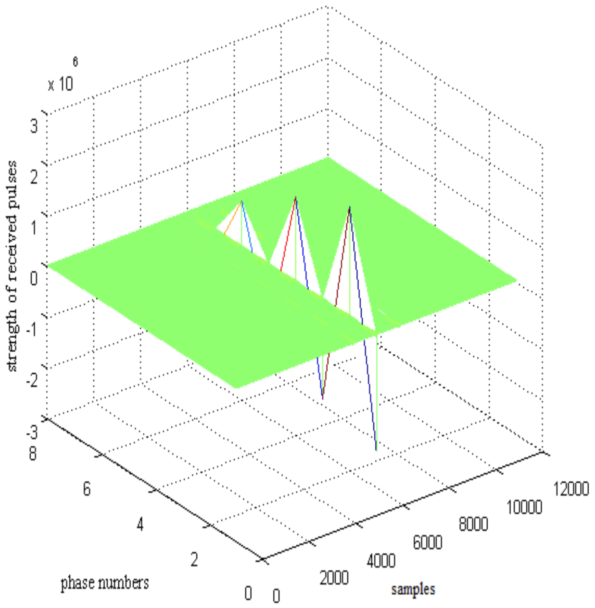

Figure 4. Target received at sum beam

Figure 5 shows the target received at difference beam

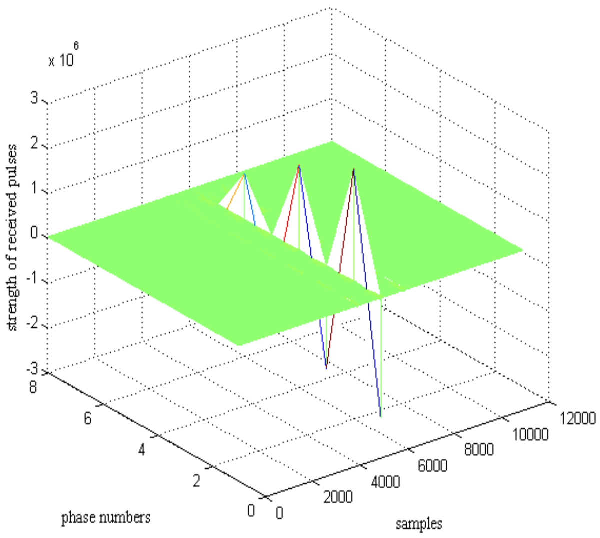

Figure 5. Target received at difference beam

Once the target has been received on the receivers it is subjected to matched filtering; wherein we convolve all received 8 PRFs with monopulse sum and difference patterns. Figure 6 shows the matched filter response of sum beam at the filter consisting of the target data.

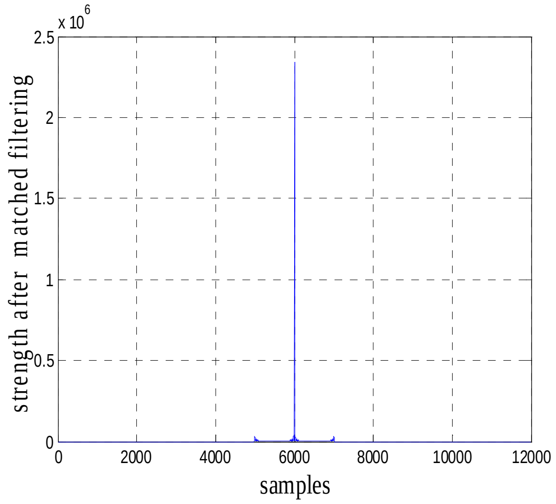

Figure 6.Matched filter response of sum beam at the filter consisting of the target data.

Figure 7 shows the matched filter response of difference beam at filter containing target data

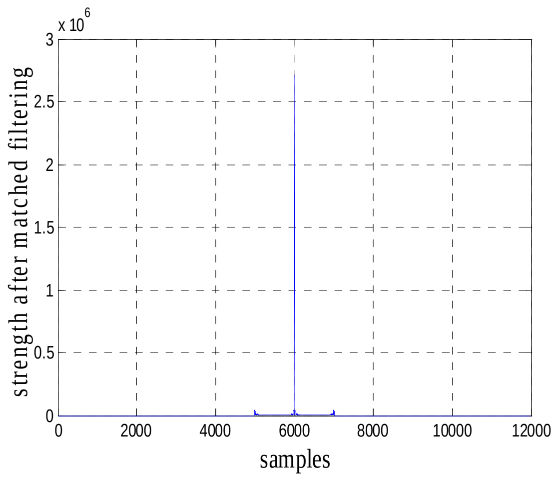

Figure7.Matched filter response of difference beam at the filter consisting of the target data.

The matched filtered output is then subjected to Doppler filtering; where we form 8 different filter banks, which comprises of concatenated match filtered responses of all the 8 PRFs. FFT algorithm is implemented on these filter banks and the response of which will have the target being separated from the clutter. The response of the Doppler filter sum beam is shown in figure 8. It can be seen that since Doppler is taken to be 5 target will be present in 5th filter.

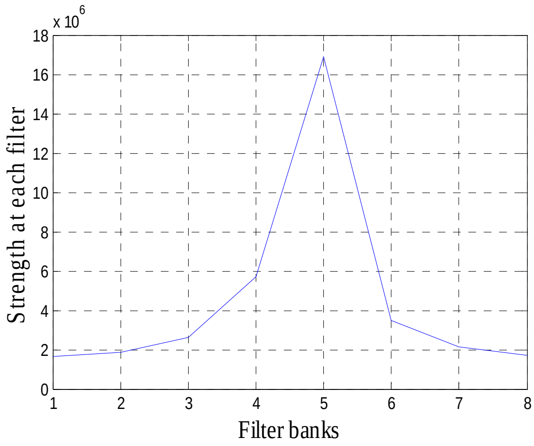

Figure 8. Doppler filter output at sum beam with target separated from clutter and target present at 5th filter which is the Doppler.

Similarly figure 9 shows Doppler filter output at difference beam.

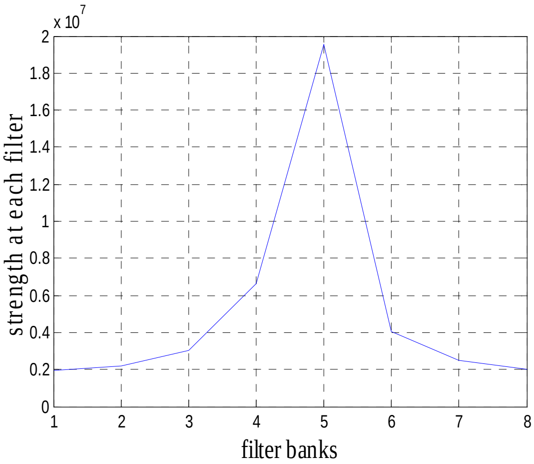

Figure 9. Doppler filter output at difference beam with target separated from clutter and target present at 5th filter which is the Doppler.

The task that follows Doppler filtering is to obtain d/s ratio and to specify offset angle of the target. To achieve this we obtain the ratio of responses at difference and sum beams at the filter where the target is said to be present. i.e. in this paper we calculate d/s ratio at 5th filter. We plot a monopulse curve shown in figure 10; for various offset angles and their corresponding d/s ratios. Hence matching the d/s ratio obtained after Doppler filtering; we determine the offset angle, and this offset angle matched with the offset introduced initially at time of reception of target echo.

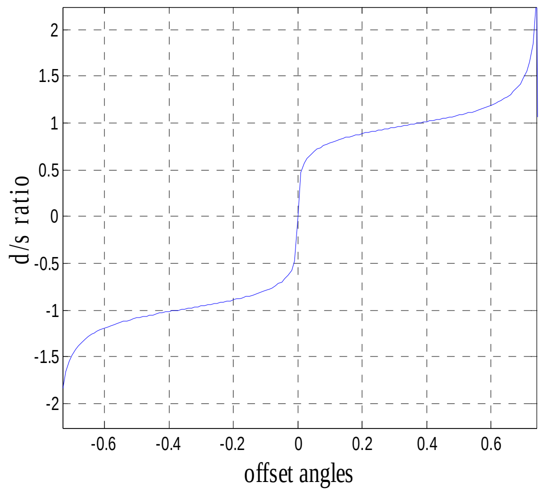

Figure 10. Monopulse curve plotted for various offset angles and their corresponding d/s ratios.

VI CONCLUSION

Simulation of the target and then testing of the monopulse processing chain with that target has been presented. Principle of Doppler filtering is included such that we can get the target filtered off in the presence of clutters. Thus Doppler filtered target is used to test monopulse chain and angular estimate of that target is obtained.

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BIODATA OF AUTHORS

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